BREEDING BIOLOGY OF THE GOLDEN EAGLE IN SOUTHWESTERN IDAHO

JOHN J. BEECHAM AND M. N. KOCHERT

In view of population declines in several species of raptors in North America and Europe in the last 25 years (Hickey 1969, Ratcliffe 1970, Cottam 1961), a great need exists for studies that help us ascertain norms in unaffected raptor populations and identify factors contributing to the declines. In this regard, in 1966 the U.S. Bureau of Sport Fisheries and Wildlife (Division of Wildlife Research and Division of Wildlife Services) initiated a study of the Golden Eagle (*Aquila chrysaetos*) in southwestern Idaho and southeastern Oregon. That preliminary field work laid the foundation for a longer-term ecological study of Golden Eagles in southwestern Idaho, the results of which are reported here. In this paper we describe nesting success, density, mortality, and evaluate current population status of Golden Eagles in southwestern Idaho.

During 1968 and 1969 we concentrated on obtaining basic information on food habits, productivity, nesting density, mortality factors, and behavior of Golden Eagles. In 1970 and 1971 our objectives were: 1. to ascertain the reproductive success and density of the breeding population; and 2, to identify certain mortality factors.

STUDY AREA AND METHODS

The principal study area was the Snake River Plain between Bliss and Marsing, Idaho, and encompassed 240 km of the Snake River. Scattered nests along the Boise, Payette, and Weiser rivers, were studied less intensively.

The Snake River Canyon forms the major geologic feature of the area. Basalt and ash cliffs, 8 to 120 m high, plus occasional benches and buttes, provided most of the nesting sites. Sagebrush flats, extending into the foothills of the Sawtooth mountain range to the north and the Owyhee range to the south, border the area and provide adequate hunting areas. Elevation of eagle eyries studied ranged from 700 m along the Snake River to 1525 m in the mountains north of Boise.

The area is in the Upper Sonoran life zone. Dominant species on the flats are sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus nauseosus*), shadscale (*Atriplex confertifolia*), and cheatgrass (*Bromus tectorum*). At higher elevations the dominant species are ponderosa pine (*Pinus ponderosa*), bitterbrush (*Purshia tridentata*), and sagebrush. Cottonwood (*Populus* sp.), willow (*Salix* sp.), and golden currant (*Ribes aureus*) occur along the river and creek bottoms. Cultivated lands, which produce largely sugar beets and potatoes, comprise approximately 18% of the study area. The uncultivated portions of the area are grazed by sheep and cattle.

Field work in 1968 began in June and continued through August. A second field season extended from February through August 1969. Field seasons in 1970 and 1971 lasted from mid-March to early September. Division of Wildlife Services maps provided the locations of many eyries. We also flew over the area in a fixed-wing aircraft in late March and early April each year to locate active nests. Systematic ground searches throughout the nesting season revealed additional active eyries. All active and alternate nest sites were plotted on U.S. Geological Survey maps.

We used standard rapelling gear and techniques to gain access to each eyrie. Productivity and nesting success data were obtained from one visit to an eyrie prior to hatching, several visits during the nestling period, and one visit after fledging. All eaglets were banded with Fish and Wildlife Service bands. Most eaglets were marked with individually color-coded neck markers (Beecham 1970) or color-coded wing markers (Kochert 1972).

Throughout the nesting season we made a special effort to collect and autopsy dead eagles.

RESULTS AND DISCUSSION

Nesting density.—The number of breeding pairs along the Snake River remained relatively stable during the earlier phases of the project: 25 pairs in 1967 (Hickman 1968), 27 in 1968, and 28 in 1969. An increase in the number of pairs occurred in 1970 (40) and in 1971 (56). Only one new site (active and alternate nests used by a breeding pair) was established in 1970, despite the major increase in number of nesting pairs located. The remaining 1970 and 1971 pairs used traditional sites. Lockie and Ratcliffe (1964) observed recolonization of ancestral sites in the Hebrides Islands when nesting density increased. One factor contributing to the increased density that they observed was increased availability of sheep and deer carrion. In our study, peaks in blacktail jackrabbit (*Lepus californicus*) densities in southwestern Idaho in 1970 and 1971 (R. Griffith, pers. comm.) probably contributed to increased numbers of known nesting pairs, but some of the increase may have been artifactual due to our increased knowledge of the study area and better detection of eagles.

The number of alternate nests per nesting site in the area ranged from 1 to 12 (mean = 6). Three pairs in 1970 and 4 in 1971 laid eggs in nests constructed the same year.

The minimum distance between active eyries ranged from 1.9 to 23.3 km in 1969, and from 0.8 to 16 km in 1971. Movement of pairs to alternate nests decreased the minimum distance observed, and discovery of previously unknown breeding pairs was responsible for the increased density. McGahan (1968) in Montana observed Golden Eagles nesting 1.6 to 16.8 km apart. Kochert (1972), using a modification of Ratcliffe's (1962) method, calculated density based on a circle around each nest with a radius of ½ the average distance between eyries. He found an average of 73 km^2 per eyrie for the 56 breeding pairs located in 1971. We found one pair per 8 km of river in 1969 and one pair per 5 km in 1971. Figures computed on a linear-kilometers-of-river basis may be a more realistic measure of density than

TABLE 1
CLUTCH SIZES OF GOLDEN EAGLES IN SOUTHWESTERN IDAHO, 1969–1971

Year	N	% of clutches with			Average clutch
		1 egg	2 eggs	3 eggs	
1969	22	5	77	18	2.1
1970	25	12	72	16	2.0
1971	42	7	79	14	2.1

those calculated on a per unit area basis, because of the artificial boundaries used in the latter method. Kochert's (1972) figure of breeding pair density (73 km^2) compares favorably with densities found in Scotland. Lockie (1964) found 13 pairs of Golden Eagles nesting at a density of one pair to 70 km^2: Brown and Watson (1964) reported the average area per pair ranged from 46 to 72 km^2 in 4 different areas in the Scottish highlands. In Montana, McGahan (1968) found one pair per 172 km^2, while Reynolds (1969) mapped an 83 km^2 area used by a pair. Dixon (1937) found an average of one pair to 93 km^2 in California.

Territorial intolerance and availability of nest sites regulated the distribution of breeding pairs along the Snake River. Territorial intolerance appeared to be the less dominant force. We observed that nest sites were widely spaced in areas of poor cliffs, whereas in areas of adequate cliffs, pairs nested in close proximity. Ratcliffe (1962) observed the same pattern with Common Ravens (*Corvus corax*) and Peregrine Falcons (*Falco peregrinus*), with densities apparently a function of the availability of suitable cliffs, up to a point where maximum density was reached.

Nesting success and productivity.—A nesting attempt was defined as the laying of at least one egg and was judged successful if one or more eaglets fledged. Ninety-three of 146 nesting attempts (65%) were successful during the study (61% in 1969, 70% in 1970, and 62% in 1971). Nesting success along the Snake River compares favorably with that in a stable population in eastern Scotland (Lockie et al. 1969) and was far above the 29% reported in a declining population in western Scotland (Lockie and Ratcliffe 1964). Nesting success ranged from 63 to 91% during a 6-year study in Montana (Reynolds 1969).

The average size of 89 clutches was 2.1 eggs (Table 1). Proportions of 1-, 2-, and 3-egg clutches did not change significantly from 1969 to 1971. Similar clutch size and frequency data were obtained by McGahan (1968) and Reynolds (1969) in Montana. We found 4 eggs in an eyrie in 1970, 2 in early April, and 2 more 3 weeks later. The adults deserted the nest, leaving 1 egg destroyed, 1 addled, and 2 fertile; we believe that the last 2 eggs laid were

TABLE 2
PRODUCTION AND NESTING SUCCESS OF GOLDEN EAGLES IN SOUTHWESTERN IDAHO 1969–1971

Year	Young hatched per: Successful nest	Young hatched per: Nesting attempt	Young fledged per: Successful nest	Young fledged per: Nesting attempt	Nesting success %
1969	2.1	1.3	1.4	0.9	61.0
1970	1.7	1.4	1.7	1.2	70.5
1971	1.6	1.1	1.8	1.1	62.2
1969–71	1.8	1.3	1.6	1.1	64.6

fertile. Ray (1928) stated that Golden Eagles seldom renest; however, Dixon (1937) believed that in southern California these birds lay a second clutch. We feel that the 4 eggs above represented 2 separate clutches, based on the interval of their appearance. Either 1 female laid 2 clutches for some unknown reason, or 1 mate died and a new one attempted to nest. Sandeman (1957) and Dixon (1937) reported prompt acquisition of new mates in Golden Eagles, but did not observe this occurring during a single nesting season. During 1969, one pair in our study laid a single egg in each of 2 nests located approximately 3 m apart. Green nesting material and freshly killed marmot (*Marmota flaviventris*) remains were found in the uppermost nest, indicating that the pair may have attempted to incubate in that nest. Both nests were abandoned before we visited them.

Hatching dates ranged from 18 March through 21 April (median 11 April) in 1969; 17 March through 12 May (median 10 April) in 1970; and 23 March through 18 May (median 13 April) in 1971. Weather conditions during April 1970 and 1971 were cooler and wetter than those during April 1969 (data from Dept. Comm. Weather Bureau), possibly accounting for the extension of the hatching period into May during 1970 and 1971.

An average of 1.3 young hatched per nesting attempt, and 1.8 hatched per successful pair during the study. Boeker and Ray (1971) reported an average of 1.5 eaglets hatched per nest during a 6-year study in the central Rockies. In our study, abandonment of nests and infertile, destroyed, and missing eggs decreased hatching success. Weather factors and accidental trampling of eggs by parents caused minor losses.

An average of 1.1 young fledged per nesting attempt, while 1.6 young fledged per successful nest during the study (Table 2). Reynolds (1969) reported 1.1 young fledged per nesting attempt during 6 years of study in Montana.

Mortality.—Causes of mortality in the Golden Eagle have received little study. Brown and Amadon (1968:128) suggested mortality during the nestling stage may claim 25 to 35% of the young. In our study, 41 of 129 (32%) young died before fledging.

Possible heat prostration accounted for the largest number (17) of dead nestlings (41% of the mortality). Five of these eaglets were autopsied and were found in good physical condition. These eaglets were discovered in nests with a western or southern aspect, thus exposed to direct sun during mid- and late afternoon. Nelson (1969:66) suggested this time of day is most critical for nestling survival in exposed nests.

Known instances of fratricide, a source of mortality that appears not to have been specifically observed before in North American Golden Eagles (W. R. Spofford, pers. comm.), resulted in the loss of 3 eaglets. Fourteen other eaglets simply disappeared from the nest, and some may have been victims of fratricide. Sumner (1934) states that fratricide may account for many missing nestlings and Ingram (1959) suggests that fratricide occurs frequently in raptors. Although Brown (1955) states that the fighting instinct in young eaglets ceases after the first few weeks (thereafter the eaglets live together amicably), we found that the fighting instinct probably did not cease. Instead, a dominance relationship developed between eaglets (Beecham 1970). In many instances in southwestern Idaho, this hierarchy expressed itself before the smaller eaglet was killed.

Among the 10 dead fledglings examined, 4 died of trichomoniasis, 2 of impact injuries, 1 was shot, and 3 died from unknown causes. Electrocution, the major cause of mortality in immature birds, killed 12 eagles. Four more immatures died of gunshot wounds, 2 of impact injuries, and 2 of unknown causes. Coon et al. (1970) reported that trauma (impact and shooting) was the major cause of mortality in 76 Bald Eagles (*Haliaeetus leucocephalus*). In our examination of 28 dead immature and adult Golden Eagles, electrocution accounted for 43% of the deaths (all immatures), impact injuries accounted for 21%, and shooting for 11%.

Movement and dispersal.—In the United States, certain populations of Golden Eagles exhibited north-south movements (McGahan 1968, Spofford 1964), while others show no extensive movements (Boeker and Ray 1971, Carnie 1954). On our study area many adult birds remained near nesting territories throughout the year. Morlan Nelson (pers. comm.) reported that adult Golden Eagles have been observed in the vicinity of nesting territories during all months of the year in southwestern Idaho.

Fourteen of 16 banded eaglets recovered during the study were found within 174 km of their natal nests. One bird was found dead near Willows, Glenn Co., California, approximately 644 km southwest of the study area. A second bird was found dead near Nephi, Juab Co., Utah, 563 km southeast of the study area.

Reported sightings of marked birds provided additional data on movements. Twelve of 14 sightings were made within 80 km of the study area. A 6-month-old bird was sighted approximately 483 km southeast of the area, and a 2-year-old was sighted approximately 507 km northwest. Sightings of marked eagles were made in all months except July.

Our tentative assessment is that dispersal appears to be random from our study area, but more data are needed to confirm this. Lockie and Ratcliffe (1964) suggest that surplus Golden Eagles, both adults and immatures, may live a nomadic existence. Forty-six of 73 (63%) of our observations of single eagles during the nesting season were of immatures. Apparently a large number of immatures range throughout the area, but do not remain in a specific area for any length of time. This large proportion of immature birds during the nesting season suggests that we have a stable population in southwestern Idaho (see Brown and Watson 1964).

CONCLUSIONS

The Snake River canyon in southwestern Idaho probably supports one of the highest densities of Golden Eagles in the United States. High nesting densities and good productivity, as compared to data from other eagle populations that are considered to be stable, indicate that Golden Eagles in southwestern Idaho are experiencing no reproductive difficulties at this time.

Three basic factors appeared to regulate Golden Eagle densities: 1, availability of preferred nesting sites; 2, adequate prey populations within the hunting range; and 3, minimum nesting territory size. We feel that our study area supported a near-maximum number of breeding pairs in 1971. Eagle densities were lowest in areas where suitable cliffs were present but most of the land was cultivated. These data suggest that although native prey species are important as a limiting factor to the population, minimum nesting territory size appears to be the factor limiting a further increase in eagle density. While Ring-necked Pheasants (*Phasianus colchicus*) formed an important part of the food brought to nests by eagles in agricultural areas, jackrabbits and cottontails (*Sylvilagus nuttallii*) still predominated (Kochert 1972, Beecham 1970), suggesting that eagles are dependent on lagomorph populations. The extensive, monocultured irrigation projects (characteristic of Desert Land Entry projects in Idaho) could result in a decrease in lagomorph densities with eagle density also decreasing. Approximately 18% of the land within 8 km of the Snake River was cultivated in 1969. Another 4050 ha of Bureau of Land Management holdings within the study area are scheduled to be cultivated each year for a minimum of 10 years (E. Tilzey, pers. comm.).

Symptoms commonly observed in declining raptor populations affected by chemical contamination (Hickey and Roelle 1969) were not evident in eagles in southwestern Idaho. Our data indicate that the eagle population was stable and reproductively healthy, with an abundance of prey, adequate nesting sites low chemical contamination (Kochert 1972), and low intensity of land use.

SUMMARY

The breeding biology of the Golden Eagle was studied along 240 km of the Snake River canyon, southwestern Idaho, from 1968 to 1971. A density of 1 eyrie per 73 km^2 (56 breeding pairs) was found in 1971, or one pair for every 5.8 km of river. An average of 2.1 eggs were laid per active nest, 1.3 young were hatched, and 1.1 young were fledged from 89 clutches from 1969 to 1971. Nesting success ranged from 61 to 70%. Forty-one of 129 (32%) eaglets died before fledging: 17 from possible heat prostration, 14 disappeared, and 10 from miscellaneous causes (including fratricide). Accounting for the deaths of 28 immature and adult eagles were: electrocution 43% (all immature birds), impact injuries 21%, and shooting 11%. Fourteen of 16 banded eaglets were recovered within 174 km of their natal nests, one from 644 km to the southwest, and one from 563 km to the southeast. A two-year-old bird was sighted 507 km northeast of the area. Dispersal appeared to be random in direction.

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TABLE 1
CLUTCH SIZE OF MARKED RING-BILLED GULL NESTS ON GRANITE ISLAND, 1973

Week of clutch initiation	Average clutch size		
	A × A	A × B	B × B
2–6 May	6.00 (1)	—	—
7–11 May	3.76 ± 0.83* (17)	—	—
12–16 May	3.49 ± 1.08 (43)	3.67 (3)	—
17–21 May	3.20 ± 1.32 (20)	3.00 ± 0.54 (8)	3.00 (1)
22–26 May	2.61 ± 0.61 (18)	3.00 ± 0.60 (12)	2.00 (1)
27–31 May	1.86 ± 0.69 (7)	2.75 (4)	2.00 (2)
1–5 June	2.29 ± 0.95 (7)	2.20 ± 0.84 (5)	1.67 (3)
6–10 June	2.00 ± 0.71 (5)	2.00 (2)	—
Total	3.14 ± 1.16 (118)	2.85 ± 0.78 (34)	2.00 ± 0.82 (7)

* Standard deviation of the mean (also in Tables 3, 4, and 5).

A × B pairs the only significant difference in any of the parameters was the mean breadth of the third egg. Although my sample size of B × B eggs is too small for statistical comparisons, the means of the parameters show all these eggs were smaller than eggs of the other pair types. Shape index values indicate B × B eggs were shorter and broader than their A × A and A × B counterparts.

For all parameters, successful eggs were numerically, but not significantly, larger than unsuccessful eggs (Table 4). Both successful and unsuccessful eggs of A × A pairs averaged larger than eggs of A × B pairs.

Mature-plumaged pairs which started their clutches on or before the mean date of clutch initiation (17 May) laid larger eggs than pairs which started their clutches after the mean date (Table 5). A similar trend occurred in A × B and B × B pairs. Only differences in egg volumes of early and late starting A × A pairs reach significance.

The differences in the median dates of laying among the 3 groups are reflected in their respective success rates. Eggs laid by mature-plumaged pairs had a hatching success approximately twice that of eggs laid by pairs with one immature-plumaged bird. All eggs of B × B pairs were destroyed by a predator, probably Common Crows (*Corvus brachyrhynchos*), within 2 days after laying of the complete clutch. A × B pairs lost 80% of their eggs to predators.